Re-interpretation of Remains of Snapper (*Pagrus auratus*) from Holocene Middens at Bass Point and Currarong, New South Wales.

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The abundant remains of snapper (*Pagrus auratus*), dated at 7,000–270 years BP, from coastal middens at Bass Point and Currarong have been re-examined and analysed. By comparing measurements of a suite of head bones with extensive reference collections, standard length (SL) ranges at different levels have been determined. This re-analysis shows that size ranges and class frequency profiles are similar between lower (or pre-hook) and upper (or hook) levels at each site and, although size ranges of both sites overlap to a large degree, the mean size (SL) of Currarong individuals is higher. The populations exhibit different structures with few (13–36 %) adults at Bass Point, in contrast to ~ 88 % adults in both levels at Currarong. To test the hypothesis that angling results in an increase in size of individual snapper harvested, the pre-hook and hook level samples at each site have been statistically compared; however no significant size difference between snapper in the two levels is demonstrated. Similarly a combined comparison, with pooled data from both sites, does not show any difference in size related to the use of fish hooks.

In addition to biological, environmental or technological factors influencing target species, it is suggested that population intensification, cultural change and variation in local economies be considered when interpreting diversity or size of fish remains in late Holocene coastal sites in New South Wales. The combination of life cycle features and behavioural traits that makes *P. auratus* susceptible to over-exploitation is briefly explained.

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INTRODUCTION

The significance of fish remains in archaeology has been internationally recognised for some years and major works, such as that by Casteel (1976), concentrated exclusively on this one category of faunal remains. Analyses of coastal middens in New South Wales have demonstrated both the wide diversity of foods used and the regular occurrence of fish remains (Godfree 1995; Leach 1979; Urqhart 1978). Sizing and identification of fish bones has been used to investigate seasonality of site occupation as well as the role of marine resources in the diets of coastal populations (Bowdler 1970,1976; Dyall 1982; Shawcross 1967; Sullivan 1984).

In Australia, the relatively recent introduction of angling has been linked to more efficient exploitation of marine resources and has been correlated with a gradual intensification of site occupation (Blackwell 1982; Sullivan 1984). Origins of angling technologies are still the subject of controversy (Attenbrow et al. 1997), but fishing with hooks and lines is reported to have first occurred in northeastern Australia 1,200–1,000 years ago (Rowland 1981; Walters 1988). It has been generally accepted that knowledge of

Figure 1. Locations of coastal Aboriginal midden sites studied and discussed, with regional population centres indicated for reference.

angling methods spread southwards along the eastern coast (Massola 1956), but these techniques were not adopted in some areas and alternative ideas for the transfer of this technology have been suggested (Walters 1988). Regardless of the mode of transfer it is clear that by 600–500 years BP angling was occurring in southeastern areas (Massola 1956; Walters 1988).

Two previous papers (Owen and Merrick 1994a,b) demonstrated that the findings of some local studies on fish remains in middens could be questioned on several grounds, including: small sample sizes; inappropriate measurements and analytical procedures; incomplete knowledge of the biology of target species or environmental influences on them; and over-simplistic assumptions about fishing techniques. The first paper (Owen and Merrick 1994a) investigated methods for accurate size and harvest determination; the second (Owen and Merrick 1994b) emphasised the selectivity of particular fishing techniques. This paper focuses on the suggestion by Bowdler (1970) that the introduction of angling resulted in an increase in the size of individual fishes harvested.

The snapper (formerly *Chrysophrys auratus* now *Pagrus auratus* (Paulin 1990)) has been one of the most important species in inshore fisheries of both temperate Australia and New Zealand during prehistoric and recent times (Anderson 1997; Anderson and McGlone 1992; Bell et al. 1991; Francis 1994a,b). Not surprisingly, snapper remains are reported to be abundant in middens on the south coast of New South Wales (Owen 1984; Owen and Merrick 1994b). Due to its commercial importance *P. auratus* has been extensively studied, especially in recent years (Bell et al. 1991; Francis 1994a,b; Francis et al. 1992; Hecht et al. 1996). New data on reproduction, growth rates, movement and population structure now permit a re-assessment of archaeological samples and their interpretation.

Sites, Excavations

Using size determination techniques outlined in Owen and Merrick (1994a), extensive series of *P. auratus* remains from Bass Point (34°36′S, 150°54′E) and Currarong (35°0′S, 150°50′E) have been re-assessed. These sites include faunal remains dated at between 7,000 and 270 years BP (radiocarbon dating). Details of the original excavations are described below. Localities (Fig. 1) and summary profiles (Fig. 2) from Bass Point are shown.

The Bass Point excavations (Bowdler 1970) covered a total of 7 m^2 (0.2% of total midden area) — to a depth of 1.15 m; materials recovered from 50 mm spits were sieved with a 4.77 mm mesh screen. Midden layers are distinguished on shell content and the site has been divided stratigraphically into four levels:

1. upper midden, base interface dated at 570 ± 75 years BP;
2. lower midden, base at depth of 400–450 mm;
3. grey sand (75–150 mm thick);
4. white sand (~ 600 mm thick) - top layers dated to 2,975 ± 145 years BP, base dated to 17,010 ± 650 years BP (Bowdler 1976: 254).

The three Currarong excavations, by Lampert (1971), are at the northern end of the Beecroft Peninsula and four levels (depth units) have been recognised for analytical purposes. Shelter 1 was excavated to a depth of 1.48 m and is dated at 1,970 ± 80 years BP at a depth of 1.10 m. Shelter 2 was excavated to 1.20 m and has a basal date of 5,540 ± 90 years BP. Shelter 3 was dug only to 0.9 m.

Specific objectives of the studies reported here are: to re-assess the size range of snapper in the archaeological remains at Bass Point and Currarong, using the bone size / fish length relationships derived from a comprehensive reference collection; to investigate size ranges of total samples from selected midden levels at each site; to relate size to the introduction of angling technology; to briefly discuss interpretation of fish remains in relation to population pressures, cultural change and modes of resource utilisation.

MATERIALS AND METHODS

Archaeological Sources, Measurements

Archaeological material examined was from collections held at the Department of Anthropology, University of Sydney, where the new snapper reference collection used for the size determination studies (Owen and Merrick 1994a) has also been lodged. This comparative series comprised material from 42 individuals (SL 132.5–479.5 mm). Details of preparation, bones selected, and exact measurement methods were fully documented in Owen and Merrick (1994a).

Using dividers and dial calipers, a total of eight measurements (seven head bones, sagittal otolith) were taken on archaeological collections, but only five characters (largest data sets) from three head bones (listed in Tables 1,2 and 3) were utilised in analyses. Each measurement , for the purposes of analysis, was considered to represent an individual.

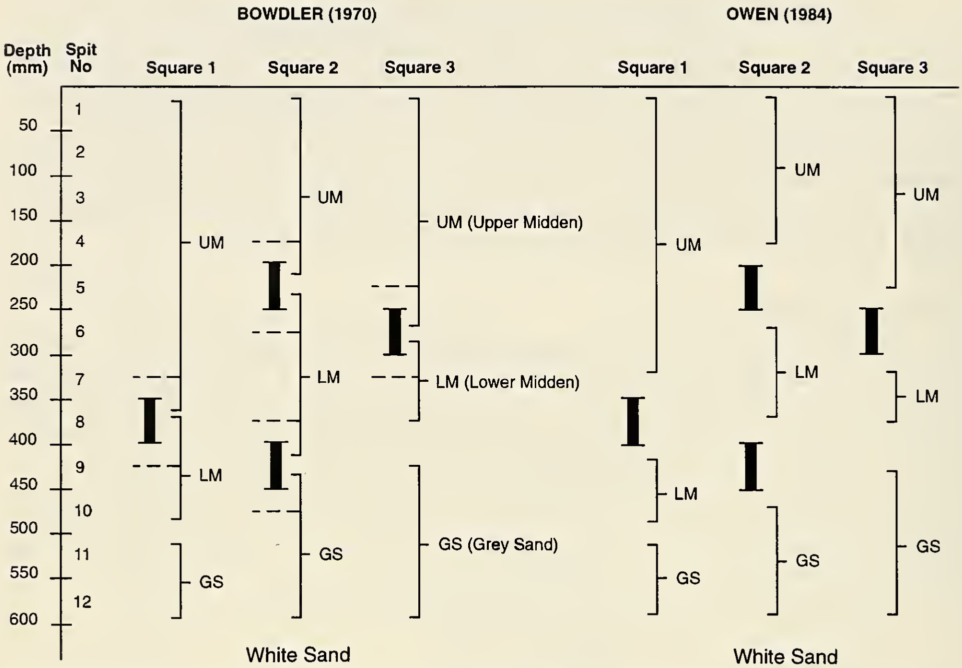

Figure 2. Midden layers exposed during two excavations at Bass Point, related to spit levels. Possible divisions between midden levels are marked (- - -) and intermediate spits not included in analyses indicated (I).

Analyses

For the linear regression analysis shown in Table 1, standard lengths (SL) for the archaeological samples were calculated to the nearest 0.1 mm. The histograms and statistical analyses have been based on total samples from upper (hook) and lower (pre-hook) levels. All specimens from intermediate areas, where there was a discrepancy between excavations (Fig. 2) or confusion about exact strata boundaries, were excluded.

For the purposes of comparing population structure the samples were divided into 40 mm size classes, from 159.95 mm to 679.95 mm, and 279.95 mm(SL) was designated as a minimal maturation size. Several two-sample t-tests (Zar 1984) quantitatively compared sizes in hook and pre-hook strata at both localities.

RESULTS

Estimated standard lengths (from each specific bone measurement) for material from different levels at both sites have been summarised in Tables 2 and 3. Length frequency histograms (Fig. 3) illustrate overall midden population structure (discussed further below) and details of t-tests are summarised in the text.

Population Structure

The total estimated size range at Bass Point was 160.6–555.6 mm SL. Figure 3a shows that an overwhelming majority (~ 87 %) of snapper harvested in recent times were in the size range 159.95–279.95 mm(SL). In pre-hook levels (Fig. 3b) about 64 % of individuals were of similar sizes; however, by extending the length range to 319.95 mm

~ 75 % of the population were included. The overall distributions of hook and pre-hook samples, although skewed, were similar with very few specimens in any size class above 319.95 mm in either level. This small number of large adults was emphasised in the histogram for the total Bass Point midden population (Fig. 3c), which shows that less than 20 % of specimens exceeded 319.95 mm.

At Currarong total estimated size range was 172.4–667.8 mm SL. The most frequent size classes at this site extended from 279.95–479.95 mm (Figs 3d and 3e) . In the hook level almost 74 % of individuals fell within this range and ~ 75 % of pre-hook specimens were in this size bracket. About 75 % of specimens, in both levels, exceeded 319.95 mm. The distribution profiles, at both levels, were similar (Figs 3d and 3e) and more regular than the Bass Point samples. This normal distribution was confirmed in the histogram for the total Currarong midden population (Fig. 3f), which shows an even normal pattern around peak frequency classes from 319.95–399.95 mm.

TABLE 1

Selected regression expressions relating specific snapper bone dimensions to standard length — calculated from *P. auratus* reference collection data (Owen and Merrick 1994a).

Bone		Bone Measurement to Standard Length(†) Relationship
Premaxilla	(process length)	y = 0.62 + 12.47 x
	(jaw length)	y = 3.12 + 9.78 x
Dentary	(height)	y = 5.80 + 30.80 x
	(jaw length)	y = 1.31 + 10.69 x
Supra-occipital	(width)	y = 3.70 + 9.84 x

† Standard length (y) is calculated using the formula y = a + bx, when a is the constant, b the exponent and x the bone measurement.

<u>Comparisons of Strata</u>

The size ranges of specimens in pre-hook (179.8–555.6 mm SL) and hook (160.6–550.8 mm SL) levels at Bass Point were similar. The t-test confirmed the null hypothesis, that there was no significant difference between the mean sizes in pre-hook ($\bar{x}$ = 285.1 mm SL) and hook ($\bar{x}$ = 254.7 mm SL) levels

$$(|t| < t_{0.05\,(2)\,88},\ 0.10 < p\,(|t| < 1.987) < 0.20)$$ at this site.

The size ranges of specimens in pre-hook (199.5–667.8 mm SL) and hook (172.4–578.6 mm SL) levels at Currarong also overlap each other, as well as the Bass Point ranges, to a large degree. Only nine (~ 3 %) out of 292 Currarong specimens were estimated to exceed the maximum size calculated for Bass Point. Again the t-test indicated that there was no significant difference in mean size between pre-hook ($\bar{x}$ = 375.5 mm SL) and hook ($\bar{x}$ = 384.2 mm SL) levels

$$(|t| < t_{0.05\,(2)\,290},\ 0.20 < p\,(|t| < 1.969) < 0.50).$$

Figures 3c and 3f clearly show that population structure at the two sites differed. To minimise site-specific influences, data from the pre-hook layers at both sites were pooled and hook layer data were pooled for a combined comparison. Although the mean standard lengths for these pooled data sets were similar, the frequency histograms (Figs 3g and 3h) illustrate different patterns with relatively high frequencies in hook levels over a wide size range (159.95–479.95 mm SL). The t-test did not demonstrate any significant difference between mean sizes (pre-hook $\bar{x}$ = 357.7 mm: hook $\bar{x}$ = 349.1 mm) of the combined samples at the two levels

$$(|t| < t_{0.05\,(2)\,380},\ 0.20 < p\,(|t| < 1.967) < 0.50).$$

TABLE 2

Estimated standard lengths (nearest 0.1 mm) of *P. auratus* from the Bass Point archaeological collection (data summarised from Owen 1984).

Bone		Fish Hook Level (Upper Midden)			Pre-Fish Hook Levels (Lower Midden)		
Measurement	n	Range	Mean	n	Range	Mean	F value
Premaxilla process length	9	165.8–492.5	272.8	5	180.8–400.2	261.8	0.031<F 0.05
Premaxilla jaw length	17	162.2–396.0	230.3	5	179.8–285.4	226.9	2.124<F 0.05
Dentary height	12	187.3–523.1	278.7	10	245.9–501.5	315.0	0.750<F 0.05
Dentary length	8	160.6–550.8	268.3	6	218.3–314.6	265.6	0.046<F 0.05
Supraoccipital width	8	190.5–266.3	236.5	10	198.4–555.6	301.9	0.272<F0.05
Total measurements (Individuals)	54	160.6–550.8	254.7	36	179.8–555.6	285.1	1.066<F 0.05

TABLE 3

Estimated standard lengths (nearest 0.1 mm) of *P. auratus* from the Currarong archaeological collection (data summarised from Owen 1984).

Site,	Fish Hook Level			Pre-Fish Hook Levels					
bone	(Depth Unit 1)			(Depth Unit 2)			(Depth Unit 3)		
measurement	n	Range	Mean	n	Range	Mean	n	Range	Mean
Shelter 1									
Premaxilla									
Process length	15	224.4–511.2	369.2	10	313.0–468.8	379.3	6	276.8–397.8	367.5
Jaw length	37	230.7–498.7	359.8	31	221.9–493.8	363.4	10	243.4–442.9	334.8
Dentary									
height	44	181.2–535.4	381.9	28	249.0–667.8	390.6	16	208.9–535.4	388.3
Jaw Length	30	172.4–578.6	411.7	21	257.9–567.9	389.1	9	205.5–512.3	349.8
Shelter 2*									
Premaxilla									
Process length	2	427.7–569.9	498.8	2	199.5–511.2	427.1	1	310.5	310.5
Jaw length	6	343.2–523.1	474.9	3	202.3–377.4	296.2	1	277.6	277.6
Dentary									
height	6	187.4–452.2	328.0	5	378.3–520.0	455.7	–	–	–
Jaw length	5	188.4–508.0	377.4	4	398.0–534.8	481.6	–	–	–
Total									
measurements (individuals)	145			104			43	(=147 total for pre-fish hook levels)	

* As data from Shelter 2 were considered insufficient for a separate analysis, these measurements were combined with the more numerous data from Shelter 1.

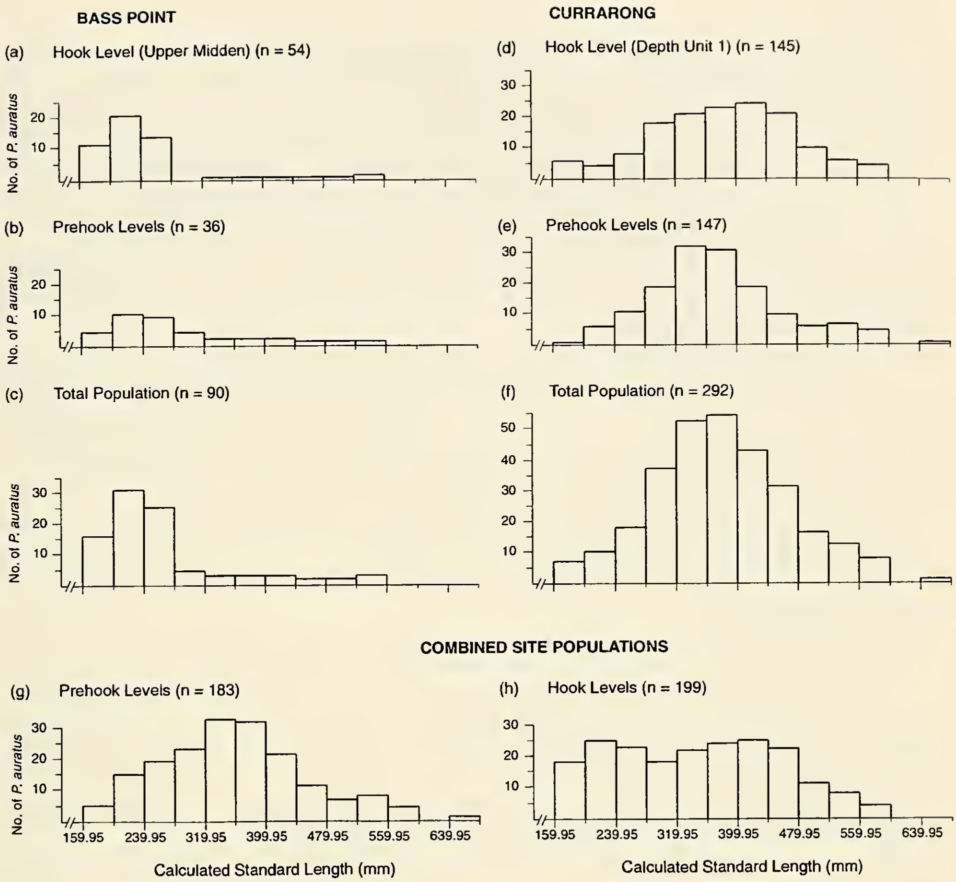

Figure 3. Relative size frequencies of archaeological snapper remains from two midden sites: (a) Bass Point - hook level; (b) Bass Point - pre-hook level; (c) total Bass Point sample, from all levels; (d) Currarong - hook level; (e) Currarong - pre-hook levels; (f) total Currarong sample, from all levels; (g), (h) combined site populations, all specimens in lower or pre-angling strata are compared with all upper or recent samples.

DISCUSSION

Although the remains measured only represent a fraction of the midden material at Bass Point and Currarong respectively, and pre-hook and hook periods differed in duration, nonetheless these samples are among the largest examined to date and the comparisons are of interest for several reasons. Previous studies (Owen and Merrick 1994a) demonstrated that a number of bone measurements can be used as accurate predictors of snapper size, but the reduced number of characters analysed here were based on the bones that occurred with the highest frequencies (largest measurement samples) at both localities. Each measurement of archaeological material had to be treated as if each bone was from a separate individual, as it was impossible to ascertain if similarly-sized paired bones were from the same individual or similarly-sized individuals. As a consequence, similar size determinations for several different bones may mean that they all came from a single individual, so the number of individuals represented may have been substantially less than the total values (n). The many factors that may influence harvests are discussed further below, but several conclusions can be drawn about the populations sampled.

Analyses

Neither the Bass Point nor Currarong samples included many large, old adults. Even the largest individuals were only about half the maximum size (~ 1200 mm: ~ 20 kg) recorded for the species (Last et al. 1983). The maturity size of 279.95 mm(SL) was selected as the point at which over 90 % of individuals were mature. Previous studies (Crossland 1977; Horn 1986) show varying percentages of maturing individuals, from ~ 50 % around 240 mm SL to 100 % at 300 mm SL, but newly mature individuals probably don't make any major contributions as breeding stock (Anon. 1984). Large percentages of snapper taken at Bass Point , in both pre-hook and hook levels, were immature with only 13–36 % adults . This suggests that the reproductive potential of Bass Point populations was limited (Anon. 1984), in contrast to Currarong where about 88 % of individuals in both levels were adults.

The size frequency profiles of the two sub-populations (hook and pre-hook groups) at each locality were similar, although the mean sizes of Currarong snapper are larger. The size ranges of *P. auratus* in pre-hook and hook layers were similar both at each site and between localities. The extended ranges at Currarong were due to a very small number of large specimens (exceeding the largest Bass Point individual) which occurred with approximately equal frequencies (~ 3 %) in both pre-hook and hook levels.

The three comparisons failed to detect any change in the mean size of *P. auratus* in connection with the use of the hook. However, a difference in the population structure at the two sites is indicated. It is impossible to explain this on present data, but contributing factors could include:

(a) more intensive harvesting at Bass Point prior to the levels (time interval) investigated, which resulted in removal of a high percentage of large adults;

(b) a genetic difference between populations with the Bass Point stocks representing a distinct genetic group that perhaps matured at a slightly smaller size. Genetic variability in other local snapper stocks, separated by similar distances, has been documented elsewhere (Smith 1990);

(c) a local difference in preferred techniques resulting in a bias towards capture of smaller, immature individuals in shallower more sheltered areas.

Technological and Cultural Change, Resource Utilisation

Despite the relatively large samples analysed, the fact that no significant differences could be established relating to the introduction of angling is not surprising. Impacts of this type of technological change would be very difficult to discern. Factors that would influence harvests, which may be reflected in midden remains, include: the many interacting biological and environmental parameters that affect growth and occurrence of fishes (Owen and Merrick 1994a); the variety of fishing techniques used concurrently and the selectivity of particular harvesting methods for target species (Owen and Merrick 1994b); and cultural change and altered resource utilisation as a result of population pressures in the late Holocene (Nicholson and Cane 1994). Whilst these studies were confined to snapper there are several general observations and recent findings which should be taken into account when analysing all coastal midden remains in southeastern Australia.

Firstly, although individual interpretations may differ over some details, recent reviews (Lourandos and Ross 1994; Nicholson and Cane 1994) have reported a steady increase in coastal Aboriginal populations for several thousand years with accelerated growth over the last 2,000 years. This population trend resulted in increased requirements for food and intensification of site occupation.

Secondly, while it is clear that most marine and estuarine habitats were harvested, there were general cultural restraints or social differences which limited pressure on individual sources. For example, the totem system prohibited some members of the community from hunting particular species and , within a tribe, youths undergoing initiation or pregnant women were not permitted certain types of food (Kohen 1994, 1995). Whilst men fished with spears and the women usually collected shellfish, the whole community participated in other activities such as netting of seasonal schools of mullet migrating along the shoreline (Nicholson and Cane 1994; Owen and Merrick 1994b; Ross et al. 1996). The hypothesis of Bowdler (1970) linking the introduction of fish hooks and altered responsibilities, with women involved in angling while men continued fishing using other techniques, has been confirmed (Attenbrow et al. 1997).

Thirdly, the recent introduction of angling coincided with maximum pressures on food resources as well as cultural change. The concentration of population meant that demands for food were higher than at any previous time. Although Owen and Merrick (1994b) point out that angling does not normally exert a great pressure, it is cumulative, especially when combined with other techniques, and even minimal culling will dramatically reduce some species. There is also some evidence of an increased variety of species captured in recent times at other south coast sites, such as Bowen Island (Blackwell 1982) and Pambula Lake (Sullivan 1984).

Fourthly, there is evidence that coastal economies varied at different sites, depending on local resources and population movements. Coastal Aboriginal populations were not static, generally concentrating on the coast in spring or summer and then becoming more evenly distributed in winter. Sites very close to the sea were often only occupied for short periods and show a higher degree of specialisation. Whereas other sites, such as Currarong, had a mixed economy. Located at the juncture of several environmental zones (woodland,estuarine, marine) with abundant and diverse resources, the occupants at Currarong were not preferentially exploiting any particular zone or resource (Nicholson and Cane 1994).

The possibility of local over-exploitation of prehistoric coastal fisheries cannot be ignored and the snapper has a number of characteristics that make it susceptible to excessive harvesting pressure. *P. auratus* is a slow-growing, late maturing (~5 years), long-lived fish (<60 years) which appears to have limited local ranges (Anon. 1984). Although breeding is in deeper marine areas, development involves a prolonged juvenile and sub-adult phase (~ 4 years) in estuaries, to a relatively large size, before migration back to marine environments to join adult stocks. The adults are also reported to come closer inshore during an extended summer spawning season (Bell et al. 1991; Hecht et al. 1996; Roughley 1963). An aggressive nature and low diet selectivity mean that this species can be readily taken by angling, using a variety of baits (Winstanley 1984).

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